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ABSTRACT

Multimarket Contact, Collusion and the Internal Structure of Firms

by Silke Neubauer

Multimarket contact has an impact on the sustainability of collusive outcomes, whenever firms or markets differ from each other or scope effects are present. An implicit assumption made in the literature dealing with multimarket contact and collusion in infinitely repeated games is the existence of a single decision taker. Nevertheless, big firms often hand over responsibility for single markets to managers, who maximize divisional profits. If markets were independent from each other, the impact of multimarket contact would vanish. In this paper, the consequences of divisionalization on the sustainability of are analyzed in a two-firm two-market framework with intra-firm scope effects. Within a divisionalized structure, each manager chooses the output of his market to maximize long-term divisional profits. Managers do not coordinate their collusion or deviation decisions. It is shown, that - dependent on the kind of scope effects - the lack of coordination between divisions may increase or decrease the collusive power of firms. If firms face economies of scope, collusion is easier to sustain within a divisionalized structure, whereas firms facing diseconomies of scope prefer centralized decision making and coordination of collusion across markets. Furthermore, the impact of the compensation scheme for managers is explored: Managers should be made to internalize negative spillover effects, but should be made to neglect positive spillovers.

ZUSAMMENFASSUNG

Mehrmarktkontakte und Organisationsstrukturen und das Kollusionsverhalten von Unternehmen

Im Rahmen von unendlich wiederholten Spielen kann gezeigt werden, daß der Kontakt von Firmen auf mehreren Märkten kooperatives Verhalten und Kollusion beeinflußt. Grund ist, dass ein Aggressor nicht nur auf einem Markt, sondern auf allen Kontaktmärkten „bestraft“ werden kann. Die Literatur geht dabei von der Existenz eines einzelnen Entscheidungsträgers aus, der Vergeltungsstrategien in den einzelnen Märkten koordiniert. Mehrmarktfirmen sind jedoch oft durch divisionalisierte Organisationsstrukturen gekennzeichnet, in welcher Entscheidungen über einzelne Märkte auf Manager übertragen wird. In diesem Beitrag wird daher der Einfluß von Delegationsentscheidungen auf die Stabilität kooperativer Gleichgewichte im Rahmen eines Zweimarktduopols untersucht. Durch das Vorliegen einer gemeinsamen Kostenfunktion sind die Märkte miteinander verbunden. Es kann gezeigt werden, daß Delegation die Stabilität kooperativer Gleichgewichte erhöht, wenn die Kostenfunktion „economies of scope“ aufweist, und reduziert, wenn negative Kostenverbindungen vorliegen. Implizite Kollusion wird folglich maßgeblich durch Organisationsentscheidungen von Firmen beeinflußt.

1. Introduction

The ability of oligopolistic firms to tacitly exploit their potential market power and achieve better outcomes than the noncooperative Nash equilibrium was first analyzed by Friedman (1971). Friedman argued, that in an infinitely repeated game the threat of future punishment can be used to enforce cooperative behavior. Starting from a collusive output level, duopolists may define future reactions to deviation from this output level (trigger- or grim strategies), by which both - the deviating as well as the punishing firm are hurt. Following Friedman, the sustainability of the collusive equilibrium can then be measured by calculating the critical discont factor that equalize the long-term gains from a collusive strategy with the gains from a deviating strategy.

In a seminal article, Bernheim / Whinston (1990) claim, that multimarket contact may help firms to sustain collusive outcomes whenever firms or markets differ from each other. They consider firms which compete in several markets. It is shown, that the possibility of these firms to punish deviation from a cooperative equilibrium in every "contact" market may relax binding incentive constraints in a wide range of circumstances. Furthermore, whenever firms differ in their production costs or scale economies are present, multimarket contact allows the development of "spheres of influence", which enables firms to sustain higher levels of profits and prices. Bernheim and Whinston assume, that markets are independent from each other. The mechanism driving their result is, that the possibility of multimarket firms to "pool" their incentive constraints across markets allows them to export "slack enforcement power" from one market to the other. Therefore, if firms and markets are the same, the pooling of incentive constraints does not alter the feasibility of collusion in each market and the multimarket contact is shown to be irrelevant.

Different cost- or demand- conditions in the contact markets are not crucial for an effect of multimarket contact on collusion. Also, the presence of profit linkages between per se identical markets may affect the stability of tacitly cooperative arrangements. If markets are linked due to a joint cost - or demand function, punishment in several markets may be considered as more or less severe, because of underlying scope effects rendering two-market collusion and punishment more or less profitable. For example, Kesteloot (1992) shows, that positive intrafirm demand spillovers (bandwagon effects) reduce the stability of collusive outcomes, whereas intrafirm snob effects have the reverse effect. Spangnolo (1996) assumes a concave utility function of multimarket firms. As multimarket contact allows to use the credible threat of simultaneous punishment in several markets, and firms fear simultaneous punishment more than the sum of single punishments, collusive outcomes are easier to achieve than without multimarket contact.

A crucial assumption for establishing the relevance of multimarket contact is that either decisions about strategies in the different markets are taken by a corporate headquarter, or single market strategies are coordinated such that the multimarket firm acts like an integrated organization.[1] Only if market strategies are coordinated across markets, incentive constraints can be pooled and slack enforcement power can be shifted from one market to the other. The existence of a single decision taker is also

[1] Alexander (1985) was the first who hinted to this implicit assumption. Lee / Tang (1994) further developed this idea, claiming that firms must play a corporate strategy for multimarket contact being effective and assuming a correlation between lateral diversification and corporate strategy.

the condition for the influence of intermarket linkages, as it gives rise to a integrated view of market strategies and its results: punishment in two markets may be considered as more severe (diseconomies of scope) or less severe (economies of scope) than in a single market context. Besides, the consequence of a strategy in one market cannot be evaluated without knowing about strategies played in the other market.

Theoretical and empirical work has so far assumed the existence of a single decision taker within the firm.[2] However, multimarket firms are mostly characterized by more complex organizational structures. In order to diminish managerial costs and / or to increase flexibility, decisions are often delegated to divisions or units, who decide independently for geographic or product markets. The threat of simultaneous punishment to deviation is then not credible any more, and the positive or negative effect of multimarket contact is affected. Profit-sharing plans and information exchange between divisions are instruments to internalize the effects of a division's strategy on other divisions' (and corporate) profits and to coordinate strategies across markets. Hereby, the incentive structure resulting from centralized decision making may be approximated. The internal structure of firms is hence of crucial importance for the effect of multimarket contact on the collusive potential of firms, and its design might serve as an instrument to support collusive strategies in a multimarket context.

In this paper, the effect of organizational devices on multimarket collusion will be analyzed in a two firm, two market context, where firms compete in quantities. As the result is straightforward for inherently independent markets that differ in their collusive potential (decentralization without coordination will always decrease firms possibilities to collude in both markets), the focus will be on a situation, where market profits are inherently linked. In particular, I will consider intermarket cost linkages within a firm due to (dis-)economies of scope. Two aspects of the organizational structure of a firm will be dealt with:

(1) The decision to delegate market responsibility to divisional managers (divisionalization vs. centralization).

(2) The decision about the incentive scheme for managers (sensitivity to jointly caused costs).

It will be shown, that delegation of decisions to independent managers facilitate collusion if firms face (not too high) economies of scope. In this case, firms would prefer to decide about cooperative strategies in each market separately, as an integrated view of markets increases the attractiveness of deviation due to the economies of scope in production. I firms face diseconomies of scope, delegation has the reverse effect and firms would prefer to coordinate strategies across markets to support collusive outcomes. The same intuition drives the result of the analysis of the effect of incentive schemes: Given a divisionalized structure in both firms, incentive schemes increasing the costs sensitivity of divisional managers and favoring the internalization of division-external effects are preferred by firms facing diseconomies of scope, whereas a low cost sensitivity would be preferred if there are economies of scope.

The structure of the subsequent analysis will be as follows: I will first introduce the basic two firm, two market model and will highlight the effect of the joint cost function on the sustainability of

[2] Recent work about the importance of the orgainzational structure was done, however, in a one-market context by Spagnolo (1998): examines the strategic use of managerial low-powered incentives as a means to sustain one-market collusion.

collusion in a centralized firm. Despite the ex ante identity of firms and market conditions, there might be situations, where collusion in only one market is sustainable. Therefore, the sustainability of one market and two market collusion are analyzed separately. In a second step, the impact of organization decisions on collusive outcomes will be analyzed. Finally, the results will be summarized.

2. A simple model with (dis-)economies of scope

Two firms ($i = 1, 2$) are considered, who are active in two markets ($k = A, B$) . Demand is linear and independent and can be expressed by the inverse demand-function:

$$\begin{aligned} p^A(x_1, x_2) &= a^A - x_1 - x_2 \qquad (market\ A) \\ p^B(y_1, y_2) &= a^B - y_1 - y_2 \qquad (market\ B), \end{aligned} \tag{1}$$

where $a^A = a^B = a$. Costs are interrelated. The following cost-function is assumed:[3]

$$C_i(x_i, y_i) = cx_i + gx_iy_i + cy_i \quad for \quad i = 1, 2. \tag{2}$$

In order to simplify the analysis, I will normalize c to zero.[4] The effect of the joint cost- (benefit-)[5] term can thus be highlighted. g will be restricted to be in the interval [-1,1]. In a simple Cournot-Nash Game, $g < -1$ would lead to overproduction and negative prices. If $g > 1$, firms would specialize each on one market, and offer the monopoly quantity ($\frac{a}{2}$) there, which would be at the same time the cooperative outcome in an infinitely repeated game.

Due to the cost interaction parameter g, costs of one division are hence increasing (decreasing) in the output of the other firm. Negative g indicate the presence of economies of scope.[6] For example, there might be positive spillovers because of learning effects, if activities are similar and the learning rate depends on cumulative joint production,[7] or network externalities when using a common resource.[8] For positive g, the firm faces diseconomies of scope by serving both markets. These may be due to congestion or switching costs when there are joint capacities,[9] increased maintenance costs of flexible techniques, increasing marginal opportunity cost of capital (imperfect capital markets) or forgone learning effects when activities are dissimilar.[10]

Given the chosen quantities of both firms in both markets, corporate costs can be evaluated according to

$$\Pi_i = x_i(a - \sum_i x_i) + y_i(a - \sum_i y_i) - gx_iy_i, \qquad i = 1, 2. \tag{3}$$

3 Bulow/Geanakoplos/Klemperer (1985) use a similar approach to model (dis-) economies of scope, but consider quadratic unit-costs of each single product.

4 This does not alter the qualitative results obtained. The resulting cost function is also used by Dixon (1992) when he considers two multiproduct firms.

5 In the following, I will only talk about joint cost, implying also the possibility of negative g (positive spillovers).

6 See Baumol / Panzar / Willig (1982) for the concept of (dis-)economies of scope.

7 See Porter (1985), p. 418.

8 See Westland (1992). For other examples involving economies of scope see for example Teece (1982), p. 53.

9 For example, the effectiveness of providing common services such as a personnel department, a computer department or managerial supervision utilized by multiple departments may decline as the extent of utilization of other departments increases. See Gal-Or (1993), p. 388, for this argument. See also Zimmermann (1979), p. 510, who talks about opportunity costs when common services (e.g. WATS telephone line) are used by several users (degradation, delay etc.), Teece (1982), p. 53, alluding to congestion effects of knowhow as a common input factor, or Westland (1992) for congestion effects in information systems.

10 Scherer / Ross (1990), p. 103 - 104 further hint at psychological studies that predict, that workers working in big firms are less satisfied with their job than workers of small firms. Therefore, big firms often pay a wage premium to their workers. Other reasons for diseconomies of scope are costs of control and coordination, which rise in the scope of a firm (managerial diseconomies).

The symmetric Cournot-Nash equilibrium implies

$$\begin{aligned} x_i &= \frac{a}{3+g} \\ y_i &= \frac{a}{3+g} \end{aligned} \tag{4}$$

and profits would be

$$\Pi_i = \frac{a^2(2+g)}{(3+g)^2}, \quad i = 1, 2. \tag{5}$$

However, in an infinitively repeated game, firms might be able to achieve better outcomes by uncooperatively choosing joint profit maximizing output strategies.

3. Collusion in an infinitively repeated game: A general framework

In a context of an infinitely repeated Cournot game, firms choose quantities in both markets at every point in time, $\{t\}_{t=0}^{\infty}$.[11] Firms are able to use punishment strategies to sustain cooperative (or collusive) outcomes. If it is assumed that deviation from a cooperative strategy is punished with Cournot-Nash competition, an equilibrium is described as a path of quantities and associated profits, where deviation from the path is punished by retreating to the Cournot-Nash solution forever. The feasibility of collusion depends on collusive profits, deviation profits, punishment strategies, and the discount factor used to evaluate future losses. According to Friedman, collusion is possible if the net gains from deviation are lower than the losses following deviation, or

$$\Pi_i^D + \frac{\delta}{1-\delta}\Pi_i^P \leq \frac{1}{1-\delta}\Pi_i^C \quad \text{for} \quad i = 1, 2. \tag{6}$$

Π_i^Θ ($\Theta \in \{D, P, C\}$) stands for profits in the case of **D**eviation, **P**unishment, or **C**ollusion and depends on both the equilibrium supply strategies and on each firm's share of the joint collusive output.

The critical discount factor that equalizes long term gains from a collusive strategy with the gains from a deviating strategy for firm i can be calculated according to:

$$\delta_i^{crit} = \frac{\Pi_i^D - \Pi_i^C}{\Pi_i^D - \Pi_i^P}. \tag{6'}$$

The optimal collusive outcome is obtained by maximizing joint collusive profits with respect to the collusive supply and the output share of each firm subject to 6. Alternatively, the sustainability of the most collusive outcome, the monopoly outcome, given output shares that minimize firms' deviation incentives could also be asked for.[12] The optimal output allocation would then have to minimize $max_i\{\delta_1^{crit}, \delta_2^{crit}\}$.

[11] In accordance with most of the models dealing with (multimarket) collusion, the focus in this analysis will be on stationary equilibria.

[12] This approach will be followed in the subsequent analysis.

4. Collusion by centralized firms with cost linkages

When centralized firms meet in several markets, they are able to punish deviation from a collusive strategy in every market in which they meet. According to Bernheim / Whinston (1990), a firm deciding to cheat would consequently also cheat in every contact market so that the sustainability of collusion in each of the markets depends on the comparison between short term gains from multimarket deviation and the long term losses resulting from punishment in every market in which contact occurs.

If markets and firms are identical and there is no linkage between markets, the feasibility of collusion in one market is independent of the strategy played in the other market, and the critical discount factor for one market collusion is the same as for collusion in each of the markets. By contrast, if markets are linked by a joint cost function, the supply decision in one market influences cost conditions in the other market and thus determines the sustainability of collusion in that market. The critical discount factor for collusion in both markets therefore differs from the discount factor for a single market even if cost and demand conditions are ex ante identical; and one market collusion might be feasible, when two market collusion is not.[13] Hence, in a multimarket model with intermarket cost linkages, the collusive equilibria implying cooperative behavior in both markets must be analyzed and so too must the feasibility of one market collusion.

This section will therefore investigate

(1) how intermarket cost linkages influence the feasibility of one market and two market collusion, and

(2) when one market collusion is easier to sustain than two market collusion, so that situations with tacit collusion in only one market may be observed.

4.1 One market collusion

One market collusion (say in market A) is feasible if the long term gains from a cooperative strategy in the market considered outweigh the short term gains from slightly undercutting the rival in period t. It will be assumed that firms play the one shot Cournot-Nash strategy (indexed by "P") in the market where no collusion takes place (market B). The relevant incentive constraint is then

$$\Pi_i^{DP}(\hat{x}_i(s_j x^{CP}), s_j x^{CP}, y_i^P) + \frac{\delta}{1-\delta}\Pi_i^{PP}(x_i^P, x_j^P, y_i^P, y_j^P) \leq \frac{1}{1-\delta}\Pi_i^{CP}(s_i x^{CP}, y_i^P), \quad i = 1, 2, \tag{7}$$

where s_i defines firm i's share of the joint collusive output in market A (x^{CP}). $\hat{x}_i(s_j x^{CP})$ determines the best one shot answer of firm i to the collusive output strategy of firm j. C, D and P stand, respectively, for **C**ollusion, **D**eviation and **P**unishment in market A (first index) and market B (second index).

It is assumed that firms have equal future preferences ($\delta_i = \delta_j = \delta$). The incentive constraint can then be rewritten:

$$\delta \geq \delta_i^* = \frac{\Pi_i^{DP} - \Pi_i^{CP}}{\Pi_i^{DP} - \Pi_i^{PP}}, \quad i = 1, 2. \tag{7'}$$

It is easy to see that collusion is easier, the higher collusive profits and the lower deviation and

[13] This peculiarity resulting from the joint cost term has not been considered so far in the literature.

punishment profits:

$$\frac{\partial \delta^*}{\partial \Pi_i^{CP}} \leq 0, \qquad \frac{\partial \delta^*}{\partial \Pi_i^{DP}} \leq 0, \qquad \frac{\partial \delta^*}{\partial \Pi_i^{PP}} \geq 0.$$

As the output shares of both firm must sum to one, we can define:

$$\begin{aligned} s_1 &= s \\ s_2 &= (1-s). \end{aligned}$$

The optimal collusive outcome solves

$$\max_{x^{CP}} x^{CP}(a - x^{CP}) - gsx^{CP}y_1^{CP} - g(1-s)x^{CP}y_2^{CP} \quad \text{(market A)}$$

$$\begin{aligned} &\max_{y_1^{CP}} y_1^{CP}(a - y_1^{CP} - y_2^{CP}) - gsx^{CP}y_1^{CP} \\ &\max_{y_2^{CP}} y_2^{CP}(a - y_1^{CP} - y_2^{CP}) - g(1-s)x^{CP}y_2^{CP} \quad \text{(market B)}, \end{aligned} \tag{8}$$

which leads to $\Pi_i^{CP}(s)$.

The optimal deviation strategy for firm i - given that firm j plays the cooperative strategy - solves

$$\begin{aligned} &\max_{x_1^{DP}} x_1^{DP}(a - x_1^{DP} - (1-s)x^{CP}) - gx_1^{DP}y_1^{DP} \quad \text{(firm 1)} \\ &\max_{x_2^{DP}} x_2^{DP}(a - sx^{CP} - x_2^{DP}) - gx_2^{DP}y_2^{DP} \quad \text{(firm 2)}. \end{aligned} \tag{9}$$

After observing the results of deviation, firms retreat to the Cournot-Nash solution. The (stationary) punishment supply therefore is the same as the supply in a simple Cournot-Nash game and the resulting profits are:

$$\Pi_i^{PP} = \frac{a^2(2+g)}{(3+g)^2}, \quad i = 1, 2.$$

Both joint collusive profits and deviation profits depend on the output shares allocated to each firm. The output shares, therefore, do not only determine the magnitude of collusive profits, but also influence the critical discount factor. The optimal allocation of joint output will maximize joint collusive profits under the condition that the incentive constraint (7) is met for both firms. In the case of economies of scope, the equal sharing of the joint output ($s = \frac{1}{2}$) at the same time maximizes joint collusive profits and minimizes $\max_i\{\delta_i^*, \delta_i^*\}$. In the case of diseconomies of scope, there is a trade-off between the impact of s on efficiency, and hence on the magnitude of joint profits, and the impact of s on the critical discount factor of both firms. Joint collusive profits are greatest with asymmetrical output shares, as specialization of each firm in each market allows leads to higher efficiency. But for g not too high the critical discount factor will be minimized for equal output shares.[14] In the absence of side payments, for a wide range of g, each firm must be allocated an output share near to $\frac{1}{2}$ to make collusion feasible at all. Therefore, $s = \frac{1}{2}$ will be assumed to be the output share chosen by firms in case of one market collusion.

[14] See Appendix A. Only if g is positive and very high, might efficient collusive outcomes where one firm monopolizes the collusive market and the other firm concentrates on the other market be possible.

Inserting punishment, deviation and collusion profits for $s = \frac{1}{2}$ into equation $7'$ yields $\delta_i^* = \delta_j^* = \delta^*$ as the critical discount factor for one market collusion (see also figure 1):[15]

$$\delta^* = \frac{(9-g^2)^2}{153 - 48g - 44g^2 + 16g^3 + 3g^4 - g^5}.$$

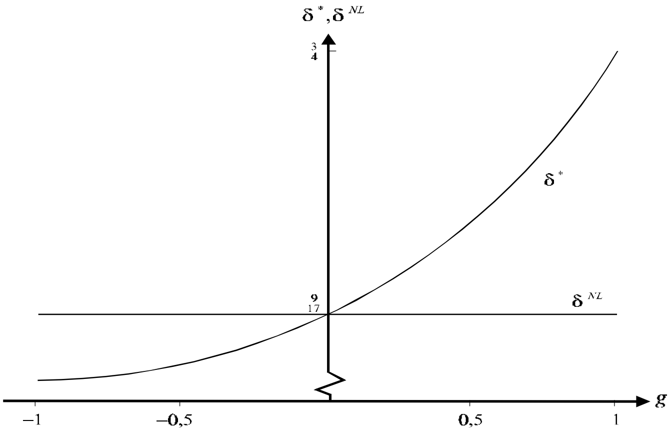

Fig. 1: One market collusion in centralized firms

In figure 1, it can be seen that the critical discount factor increases in g. When $g = 0$, it equals $\frac{9}{17}$. This is the situation faced by a firm without cost linkages (**N**o **L**inkage). Therefore, we can define

$$\delta^{NL} = \frac{9}{17}$$

as the critical discount factor of (two market) firms with independent markets. Comparison between the critical discount factors for one market collusion when firms face cost linkages with the critical discount factor of firms without cost linkages yields:[16]

$$\begin{array}{lllll} \delta^* & < & \delta^{NL} & \text{for} & g < 0 \\ \delta^* & \geq & \delta^{NL} & \text{for} & g \geq 0. \end{array}$$

The following proposition can now be stated:

Proposition 1 *Given Cournot-Nash competition in one market, the feasibility of collusion in the other market is decreasing in g. By comparison with a situation where there are no cost linkages, one market collusion is easier with positive cost spillovers and more difficult with negative cost spillovers.*

4.2 Two market collusion

The feasibility of collusion in both markets is determined by the following incentive constraint:[17]

$$\Pi_i^{DD}(\hat{x}_i(s_j^A x^{CC}),\ \hat{y}_i(s_j^B y^{CC}),\ s_i^A x^{CC},\ s_j^B y^{CC}) + \frac{\delta}{1-\delta}\Pi_i^{PP}(x_i^P, x_j^P, y_i^P, y_j^P)$$

[15] The critical discount factors are equal for both firms, as output is allocated evenly to each firm.

[16] See Appendix B.

[17] The separation of incentive constraints for both markets can never be optimal. As two market punishment is a more severe punishment for deviation than one market punishment, it relaxes the incentive constraint of firms for each single market. See Appendix C for a proof.

$$\leq \frac{1}{1-\delta}\Pi_i^{CC}(s_i^A x^{CC}, s_i^B y^{CC}), \qquad i=1,2. \tag{10}$$

s_i^k is firm i's share of the joint collusive output in market A (x^{CC}) and market B (y^{CC}) and $\hat{x}_i(s_j^A x^{CC})$ and $\hat{y}_i(s_j^B y^{CC})$ are the best one shot answers of firm i to the collusive output strategy of firm j. C, D and P again stand, respectively, for **C**ollusion, **D**eviation and **P**unishment in market A (first index) and market B (second index).

Firms' future preferences must then meet

$$\delta \geq \delta_i^{**} = \frac{\Pi_i^{DD} - \Pi_i^{CC}}{\Pi_i^{DD} - \Pi_i^{PP}} \quad \text{for } i=1,2. \tag{10'}$$

As before, both collusive and deviation profits depend on the output share allocated to each firm and the output shares play a crucial role for the determination of the critical discount factor.

Replacing

$$s_2^A = 1 - s_1^A, \qquad s_1^B = 1 - s_2^B$$

and assuming[18]

$$s_1^A = s_2^B = s \quad \text{and } s_2^A = s_1^B = (1-s),$$

joint collusive profits (Π^{CC}) are determined by

$$\Pi^{CC} = x^{CC}(a - x^{CC}) + y^{CC}(a - y^{CC}) - 2gs(1-s)x^{CC}y^{CC}. \tag{11}$$

Profits of each firm are accordingly

$$\begin{aligned}\Pi_1^{CC} &= sx^{CC}(a - x^{CC}) + (1-s)y^{CC}(a - y^{CC}) - gs(1-s)x^{CC}y^{CC} \\ \Pi_2^{CC} &= (1-s)x^{CC}(a - x^{CC}) + sy^{CC}(a - y^{CC}) - gs(1-s)x^{CC}y^{CC}.\end{aligned} \tag{12}$$

Maximization of Π^{CC} with respect to x^{CC} and y^{CC} yields $\Pi^{CC}(s)$.

A deviating firm maximizes

$$x_i^{DD}(a - x_i^{DD} - sx^{CC}) + y_i^{DD}(a - y_i^{DD} - (1-s)y^{CC}) - gx_i^{DD}y_i^{DD}, \quad i \neq j \tag{13}$$

over x_i and y_i, which leads to $\Pi_i^{DD}(s)$.

After observing deviation, firms retrieve the Cournot-Nash-solution, and punishment profits are

$$\Pi_i^{PP} = \frac{a^2(2+g)^2}{(3+g)^2}.$$

As in the case of one market collusion, for $g < 0$, an equal output share of each firm in each market ($s = \frac{1}{2}$) maximizes collusion profits due to the optimal utilization of positive spillover effects. At the same time it minimizes deviation profits. Therefore it must be the optimal output share for two market collusion. In the case of diseconomies of scope, an increase in the asymmetry of output shares ($s \to 1$) increases collusion profits, but at the same time increases deviation profits.[19]

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[18] This assumption implies a fair allocation of market shares and equalizes and minimizes the critical discount factors of both firms ($\min_s \max_i\{\delta_i^{**}, \delta_j^{**}\}$).

[19] See Appendix D.

It can be shown that for positive but low, g there is a trade-off between the efficiency gain that can be achieved by specialization and an unfavorable effect of complete specialization on the critical discount factor due to higher deviation incentives. If diseconomies of scope are becoming more important ($g \geq -2+\sqrt{5}$), the efficient collusive outcome (asymmetrical output shares of both firms) at the same time leads to a local minimum of the critical discount factor.[20]

Inserting collusion, deviation and punishment profits for symmetrical or asymmetrical output shares yields the critical discount factor for two market collusion:

$$\begin{aligned} \delta^{**}(s &= \frac{1}{2}) = \frac{(3+g)^2}{2(3+g)^2-1} \\ \delta^{**}(s &= 1) = \frac{(1-g)^2(3+g)^2}{13-4g+g^2+2g^3}. \end{aligned}$$

Figure 2 shows $\delta^{**}(\hat{s})$, the critical discount factor for two market collusion in dependence on g, based on the output share $\hat{s}$ of each firm in one market which minimizes the critical discount factor $\delta^{**}(s)$.[21]

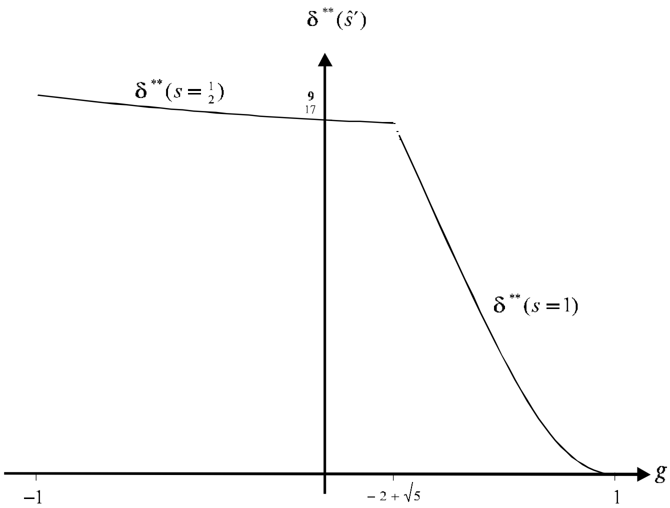

Fig. 2: Two market collusion in centralized firms

Comparison with the situation without cost linkages (NL) yields

$$\begin{aligned} \delta^{NL} &< \delta^{**}(\hat{s}) \quad for \quad g > 0 \\ \delta^{NL} &\geq \delta^{**}(\hat{s}) \quad for \quad g \leq 0. \end{aligned}$$

This leads to

Proposition 2 *The potential of two market firms with intrafirm cost spillovers to collude in two markets increases in g.*

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[20] See Appendix D.

[21]

$$\hat{s} = \begin{cases} \frac{1}{2} & for \quad g <\approx 0.21 \\ 0 < s < \frac{1}{2} & for \quad \approx 0.21 \leq g < -2+\sqrt{5} \\ 1 & for \quad g \geq -2+\sqrt{5} \end{cases}$$

(see also Appendix D).

Collusion is easier with than without cost linkages if firms face diseconomies of scope, and more difficult if firms face positive economies of scope.

4.3 Collusion in one or two markets?

As firms prefer collusive outcomes to Cournot-Nash outcomes, they will try to achieve the cooperative equilibrium in both markets whenever their incentive constraint for two market collusion is met. Hence, we would only expect to observe one market collusion, if it is easier sustainable than two market collusion, or:

$$\delta^{**} = \frac{\Pi_i^{DD} - \Pi_i^{CC}}{\Pi_i^{DD} - \Pi_i^{PP}} > \delta_i \geq \delta^* = \frac{\Pi_i^{DP} - \Pi_i^{CP}}{\Pi_i^{DP} - \Pi_i^{PP}}.$$

Comparing δ^{**} and δ^* it can be seen, that

$$\begin{array}{lcll} \delta^* & < & \delta^{**}(\hat{s}) & \text{for} \quad g < 0 \\ \delta^* & \geq & \delta^{**}(\hat{s}) & \text{for} \quad g \geq 0 \end{array}$$

(see also figure 3).

This leads to

Proposition 3 *One market collusion is easier to achieve than two market collusion if there are positive cost spillovers. It is more difficult to achieve than two market collusion if firms face negative cost linkages.*

Figure 3 compares the feasibility of one market collusion (δ^*) and two market collusion (δ^{**}) in centralized firms:

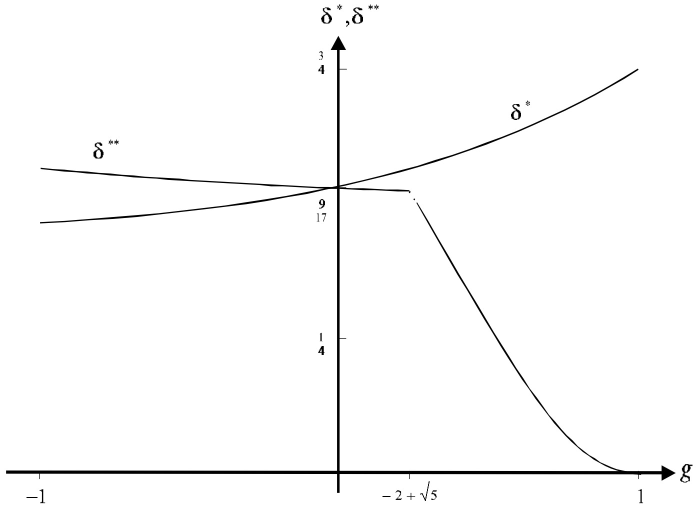


Fig. 3: One vs. two market collusion in centralized firms

5. Sustainability of collusive outcomes in decentralized firms

In the above section it was shown that positive cost spillovers render collusion more difficult, whereas negative cost spillovers facilitate collusion. This result is due to firms' evaluation of two market punishment compared with deviation or collusion. Two market punishment is a more efficient threat if there are diseconomies of scope, as high production in both markets not only leads to a negative revenue effect, but also to an increase in costs. By contrast, if firms face economies of scope, the threat of two market punishment is less severe: even though Cournot-Nash competition leads to lower profits than a collusive outcome, there is no negative cost effect. In addition, two market deviation is extremely attractive because of the existence of economies of scope.

However, these results are based on the assumption of a central decision maker who (1) coordinates strategies across markets and (2) evaluates their impact on the profits of the corporate firm. If market decisions are delegated to divisional managers, each responsible for his own divisional profits and each being allocated a percentage of the jointly caused costs, those two conditions might no longer hold:

(1) Market strategies are not per se coordinated between markets. In particular, a divisional manager cannot ensure that the other divisional manager follows a punishment strategy if deviation in his market has occurred.

(2) The effect on corporate profits of a strategy in market k may not be considered. In particular, the degree to which corporate profit effects are internalized by managers of the division depends on degree of allocation of joint costs and the compensation scheme chosen for them.

In spite of the lack of coordination between divisions, there are indirect effects of deviation and punishment strategies of one division on the collusive strategy of the other division. The switch to a punishment strategy after deviation, for example, in market A changes cost conditions and collusive profits in market B and may lead to a collapse of collusion in that market, too. This again influences the profits of division A. A manager of market A would therefore have to consider the long term cost effects of deviation in his market resulting from a possible future change in supply strategies in the other market.

In this section, the sustainability of collusive outcomes in divisionalized firms will be explored, where managers are evaluated on the basis of divisional revenue and a percentage of the costs caused jointly with the other division.

5.1 The setting

It is now assumed that decisions are delegated to divisional managers. Divisional managers receive a bonus based on divisional profits:[22]

$$\begin{aligned} S_i^A &= S_0 + \beta_0(x_i(a^A - x_1 - x_2) - C_i^\Phi(x_i, y_i)) \\ S_i^B &= S_0 + \beta_0(y_i(a^A - y_1 - y_2) - C_i^\Phi(x_i, y_i)), \end{aligned} \tag{14}$$

where

$$C_i^\Phi(x_i, y_i) = \lambda g x_i y_i, \quad 0 \leq \lambda \leq 1.$$

λ determines the cost sensibility of managers. If $\lambda = 1$, total joint costs are allocated and divisions completely internalize corporate cost effects. $\lambda = 0$ implies that joint costs are not allocated to divisions and managers do not take account for the effect of their supply strategies on corporate profits.

[22] As firms and divisions symmetrical, it is assumed that both the percentage of divisional profits and the fixed part of managers' salary are the same in both firms and both divisions.

Being only interested in monetary rewards, managers maximize their salary over x_i (managers of divisions A) and y_i (managers of division B). Future preferences of the divisions do not differ:

$$\delta_i^A = \delta_i^B = \delta.$$

A division of firm i may collude with a division of firm j in the same market. As asymmetric output shares render collusion extremely difficult, it is assumed that both firms' divisions agree on equal share of the collusive supply ($s_1^k = s_2^k = \frac{1}{2}$).[23] Deviation is punished within the market but can never be punished across markets. A firm's divisions do not share information about their deviation strategies. Nevertheless, they observe deviation in the other market and anticipate changed cost conditions in the following period. Their incentive constraints depend on production decisions taken by the other division - and hence the collusive strategy played in the other market - and on the cost allocation scheme applied.

5.2 One market collusion

As markets, firms, and divisions are symmetrical, deviation and punishment profits do not differ between firms and markets, so that the incentive constraints and critical discount factors are the same for all divisions.[24] Therefore, deviation incentives will be explored with a focus on one market (say market A). The same results hold for the divisions operating in market B.

One market collusion is sustainable, if

$$\Pi_i^{\Phi ADP} + \frac{\delta}{(1-\delta)}\Pi_i^{\Phi kPP} \leq \frac{1}{(1-\delta)}\Pi_i^{\Phi ACP}, \quad i = 1,2 \tag{15}$$

or

$$\delta \geq \delta^{\Phi *} = \frac{\Pi_i^{\Phi ADP} - \Pi_i^{\Phi ACP}}{\Pi_i^{\Phi ADP} - \Pi_i^{\Phi APP}}. \tag{15'}$$

Profits in the case of collusion in market A result from maximization of joint profits in market A and divisional profits in market B:

$$\begin{aligned}
Max_{s^A, x^{CP}} \Pi^{\Phi ACP} &= x^{CP}(a - x^{CP}) - \lambda g \frac{x^{CP}}{2} y_1^{CP} - \lambda g \frac{x^{CP}}{2} y_2^{CP} \\
Max_{y_2^{CP}} \Pi_1^{\Phi BCP} &= y_1^{CP}(a - y_1^{CP} - y_2^{CP}) - \lambda g \frac{x^{CP}}{2} y_1^{CP} \\
Max_{y_2^{CP}} \Pi_2^{\Phi BCP} &= y_2^{CP}(a - y_1^{CP} - y_2^{CP}) - \lambda g \frac{x^{CP}}{2} y_2^{CP},
\end{aligned}$$

which yields:

$$\Pi_i^{\Phi ACP} = \frac{2a^2(3-\lambda g)^2}{(12-\lambda^2 g^2)^2}$$

[23] As divisions do not participate in profits of the other division, a division being allocated a low output share cannot alleviate its disadvantage in its own market by concentrating on a second market. The monopolization of one market by one division is therefore never feasible: punishment profits are alway higher than collusive profits. The minimal discount factor for both firms (for one or two market collusion), $min_s \max_i \{\delta_1^{k*(*)}, \delta_2^{k*(*)}\}$, is obtained for symmetrical output shares. See also Appendix E.

[24] Again, this assumption can be made only because $s = \frac{1}{2}$.

$$\Pi_i^{\Phi BCP} = \frac{a^2(4-\lambda g)^2}{(12-\lambda^2 g^2)^2}.$$

A deviating market A division maximizes

$$\Pi_i^{\Phi ADP} = x_i^{DP}(a - x_i^{DP} - \frac{x^{CP}}{2}) - \lambda g x_i^{DP} y_i^{CP} \qquad i \neq j$$

with respect to x_i^{DP}, resulting in

$$\Pi_i^{\Phi ADP} = \frac{9a^2(3-\lambda g)^2}{4(12-\lambda^2 g^2)^2}.$$

Punishment profits - given Cournot-Nash play in market B - are:

$$\Pi_i^{\Phi kPP} = \frac{a^2}{(3+\lambda g)^2}.$$

Inserting Punishment, Collusion and Deviation profits in the incentive constraint for one market collusion (14') yields the critical discount factor for one market collusion, $\delta_i^{\Phi *} = \delta_j^{\Phi *} = \delta^{\Phi *}$:

$$\delta^{\Phi *} = \frac{(9-\lambda^2 g^2)^2}{153 - 66\lambda^2 g^2 + 5\lambda^4 g^4}.$$

Figure 4 below shows the critical discount factor as a function of g for $\lambda = 1$.

One market collusion is more difficult, the higher is the cost sensibility of managers and the more important the perceived spillover effects. This result can be explained by analyzing the influence of g on gains from collusion and deviation. The higher the perceived costs, the lower the gain from collusion in relation to Cournot-Nash play, but deviation incentives remain important.

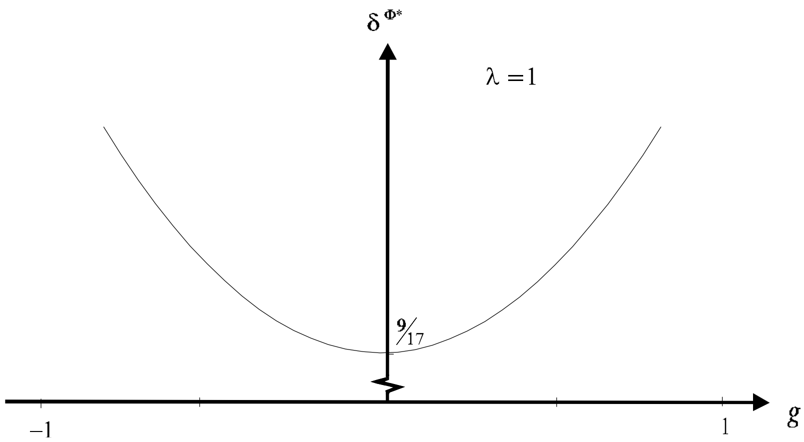


Fig.:4: One market collusion in decentralized firms

5.3 Two market collusion

Despite the delegation of supply strategies to managers, collusion decisions in each market are, due to the cost interaction term, interdependent: Departing from two market collusion, deviation of one manager (say manager A) implies a change of cost conditions for manager B and hence influences the sustainability of collusion in market B in the next period. The strategy played in market B in the next period, however, determines the expectations about future costs of manager A and influences his incentive constraint. The incentive constraint of each manager hence depends on his assumptions about what will happen in the other market after deviation in his market. In particular, it is influenced by the sustainability of collusion in one single market. Two cases must be distinguished:

(1) Deviation in one market leads to a collapse of collusion in the other market in the next period. It is assumed that divisions of the other market switch to Cournot-Nash play if the collusive outcome can no longer be sustained.[25]

(2) After deviation in one market, collusion in the other market can be sustained.

It can be shown that, in the case of economies of scope ($g < 0$), two market collusion is only and always feasible, when collusion in one market can be sustained.[26] The critical discount factor for two market collusion, $\delta^{\Phi**}$, therefore equals the critical discount factor for one market collusion, $\delta^{\Phi*}$:

$$\delta^{\Phi**} = \delta^{\Phi*} = \frac{(9-\lambda^2 g^2)^2}{153 - 66\lambda^2 g^2 + 5\lambda^4 g^4}.$$

For diseconomies of scope $g > 0$, case (1) is the relevant case:[27] Due to the diseconomies of scope, collusion in two markets is easier to sustain than in one market only and managers expect a collapse of collusion in the other market after deviation in the own market. The relevant incentive constraint is therefore

$$\Pi_i^{\Phi ADC} + \frac{\delta}{(1-\delta)}\Pi_i^{\Phi kPP} \leq \frac{\delta}{(1-\delta)}\Pi_i^{\Phi kCC} \tag{16}$$

or

$$\delta \geq \delta^{\Phi**} = \frac{\Pi_i^{\Phi ADC} - \Pi_i^{\Phi kCC}}{\Pi_i^{\Phi ADC} - \Pi_i^{\Phi kPP}}. \tag{16'}$$

Φ is an index for the cost allocation scheme applied by owners, $k = A, B$ stands for the considered division and the last two indices determine the strategy (P, C or D) in market A (first index) and B (second index).

We already solved for punishment profits, implying Cournot-Nash play in both markets ($\Pi_i^{\Phi kPP}$):

$$\Pi_i^{\Phi kPP} = \frac{a^2}{(3+\lambda g)^2}.$$

Collusion and deviation profits of each firm's division in one market, given collusion in the other market, are obtained by solving

$$\begin{aligned} Max_{x^{CC}}\Pi^{\Phi ACC} &= x^{CC}(a - x^{CC}) - \frac{1}{2}\lambda g x^{CC} y^{CC} \\ Max_{y^{CC}}\Pi^{\Phi BCC} &= y^{CC}(a - y^{CC}) - \frac{1}{2}\lambda g x^{CC} y^{CC}, \end{aligned} \tag{17}$$

and

$$\begin{aligned} Max_{x_i^{DC}}\Pi_i^{\Phi ADC} &= x_i^{DC}(a - \frac{x^{CC}}{2} - x_i^{DC}) - \lambda g x_i^{DC}\frac{y^{CC}}{2} \\ Max_{y_i^{CD}}\Pi_i^{\Phi BCD} &= y_i^{CD}(a - \frac{y^{CC}}{2} - y_i^{CD}) - \lambda g \frac{x^{CC}}{2} y_i^{CD}, \end{aligned} \tag{18}$$

[25] This is consistent with the approach to ask for the most collusive outcome (see section 2).

[26] See Appendix F.

[27] See Appendix F.

which yields

$$\Pi_i^{\Phi kCC} = \frac{2a^2}{(4+\lambda g)^2}$$

and

$$\Pi_i^{\Phi ADC} = \Pi_i^{\Phi BCD} = \frac{9a^2}{4(4+\lambda g)^2}.$$

The critical discount factor for two market collusion in the case of diseconomies of scope can be calculated by inserting deviation, collusion, and punishment profits into $16'$:

$$\delta^{\Phi **} = \frac{(3+\lambda g)^2}{17+22\lambda g+5(\lambda g)^2}.$$

(See also figure 5).

The following proposition can now be stated:

Proposition 4 *When owners delegate quantity decisions to divisional managers, collusion in both markets can be sustained, if*

$$\delta \geq \delta^{\Phi **} = \begin{cases} \delta^{\Phi *} = \frac{(9-\lambda^2 g^2)^2}{153-66\lambda^2 g^2+5\lambda^4 g^4} & for \quad g<0 \text{ (economies of scope)} \\ \frac{(3+\lambda g)^2}{17+22\lambda g+5(\lambda g)^2} & for \quad g \geq 0 \text{ (diseconomies of scope).} \end{cases}$$

Figure 5 shows the critical discount factor for two market collusion when there is decentralized decision making:

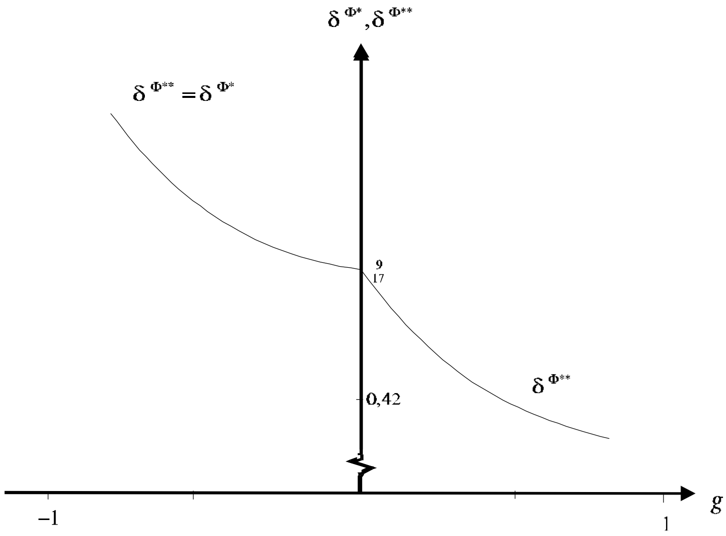


Fig. 5: Two market collusion in decentralized firms

5.4 One market collusion vs. two market collusion in decentralized firms

If we compare the critical discount factors for one market collusion and two market collusion in decentralized firms, it can be seen, that one market collusion is at least as difficult to sustain than collusion in both markets:[28]

[28] See also Appendix F.

In the case of economies of scope, the critical discount factor for two market collusion equals the discount factor for one market collusion. Only if collusion is sustainable in one market, is it also sustainable in two markets. This is due to the influence of supply strategies of either manager on the allocated costs of the other manager: if there are positive spillover effects, a higher supply in market B market favors the costs of a market A manager. Hence, deviation of manager A is more attractive if it leads to a collapse of collusion and subsequent Cournot Nash play in the other market than if collusion would be sustainable in the other market in future periods. Consequently, collusion in two markets is easier to sustain if collusion in only one market is feasible. The latter implies that the relevant critical discount factor for two market collusion is the same than the critical discount factor for one market collusion.

In the case of diseconomies of scope, collusion in one market is more difficult to sustain than collusion in both markets. If there is collusion in both markets, a manager fears the collapse of collusion in the other market after deviation in his market because of the subsequent negative effects on his costs. In the case of one market collusion, deviation does not lead to any additional effects on costs because the manager of the other division will not alter his supply strategy in the subsequent period. Punishment profits in relation to deviation profits are therefore perceived as less severe in the case of one market collusion, rendering two market collusion easier than one market collusion. Building on the previous analysis we can therefore state:

Proposition 5 *If supply decisions are delegated to divisional managers, one market collusion is at least as difficult as collusion in two markets. If one market collusion occurs, collusion is always also sustainable in both markets.*

Figure 6 shows the critical discount factors for one market collusion ($\delta^{\Phi*}$) and two market collusion ($\delta^{\Phi**}$):

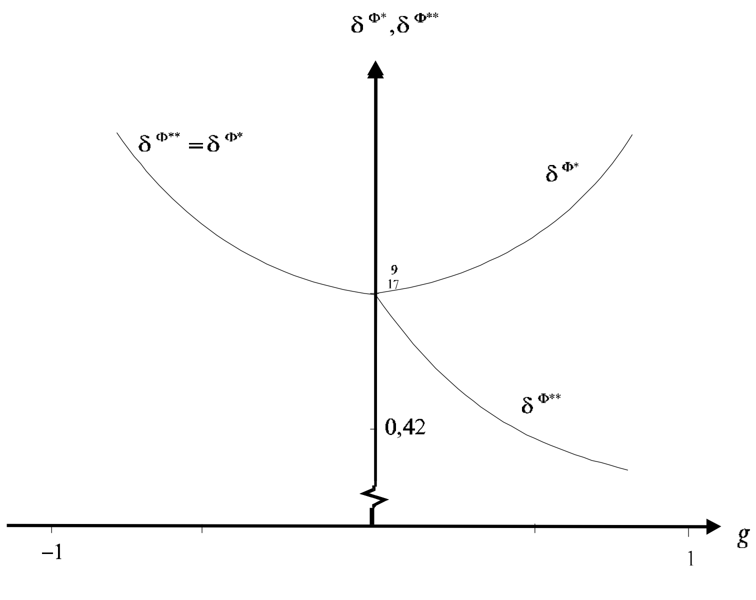


Fig. 6: One vs. two market collusion in decentralized firms

6. The impact of the organizational structure on collusion

In this section, the influence of decentralization and the incentive schemes for managers on the feasibility of collusion in two market firms is analyzed. The delegation of decisions to managers is a device for separating incentive constraints across markets, while cost allocation decisions serve as a device for influencing managers' sensitivity to the consequences of their supply strategies on future costs.

6.1 The impact of managers' incentive scheme

As the degree to which joint costs are allocated to each division, λ, influences the degree to which costs external to the division are internalized, it also influences how sensitive divisions are to deviation or punishment strategies of other divisions. In order to explore the impact of the cost allocation scheme on the collusive potential of divisionalized firms, the effect of λ on $\delta^{\Phi *}$ (one market collusion) and $\delta^{\Phi **}$ (two market collusion) must be analyzed.

λ determines linearly the level of perceived scope effects. The impact of λ on the critical discount factor therefore qualitatively equals the impact of g on a division's collusive potential. Drawing on the results of section 4, one would then suspect that one market collusion becomes the more difficult, the higher λ; and that the potential for two market collusion decreases in λ only in the case of economies of scope (punishment is considered less and less severe), whereas a high λ facilitates collusion in the case of diseconomies of scope. In fact, it can be shown, that[29]

$$\frac{\partial \delta^{\Phi *}}{\partial \lambda} \geq 0$$

and

$$\frac{\partial \delta^{\Phi **}}{\partial \lambda} \begin{cases} = \frac{\partial \delta^{\Phi *}}{\partial \lambda} > 0 & if \quad g < 0 \\ \leq 0 & if \quad g \geq 0. \end{cases}$$

The following proposition can therefore be derived:

Proposition 6 *If firms are divisionalized and interdivisional cost linkages exist, the choice of the cost allocation scheme influences the collusive potential of divisions:*
** One market collusion is the easier, the less divisions perceive (positive or negative) spillover effects.*
** Two market collusion is the easier the less divisions perceive (positive) spillover effects and the more divisions perceive (negative) spillover effects.*

Hence, in order to induce collusion in both markets, owners should choose not to allocate joint costs at all to managers, if there are positive spillovers *(* $\lambda = 0$), and should allocate total joint costs if there are diseconomies of scope *(* $\lambda = 1$).

6.2 Delegation vs. centralization

In centralized firms, deviation and punishment strategies are coordinated across markets. Besides, if there are diseconomies of scope and firms collude in two markets, firms are able to divide up markets and hence to obtain efficiency gains. By contrast, if divisional managers decide about strategies in

[29] See Appendix G.

each market, decisions about collusion, deviation or punishment are taken independently. Additionally, as managers strive at maximizing divisional profits asymmetric output shares are not achievable and efficiency gains due to the establishment of home markets are not obtainable. Therefore, we expect a difference in the collusive potential of centralized and decentralized firms.

Comparison of the critical discount factors for collusion in one market in centralized and decentralized firms yields:[30]

$$\begin{array}{lll} \delta^{\Phi *} > \delta^{*} & for & g < 0 \\ \delta^{\Phi *} \leq \delta^{*} & for & g \geq 0. \end{array}$$

Hence delegation makes one market collusion more difficult if firms face economies of scope, but it facilitates collusion in the case of economies of scope.

Figure 7 compares the critical discount factors for one market collusion in centralized and decentralized firms for $\lambda = \frac{1}{2}$:

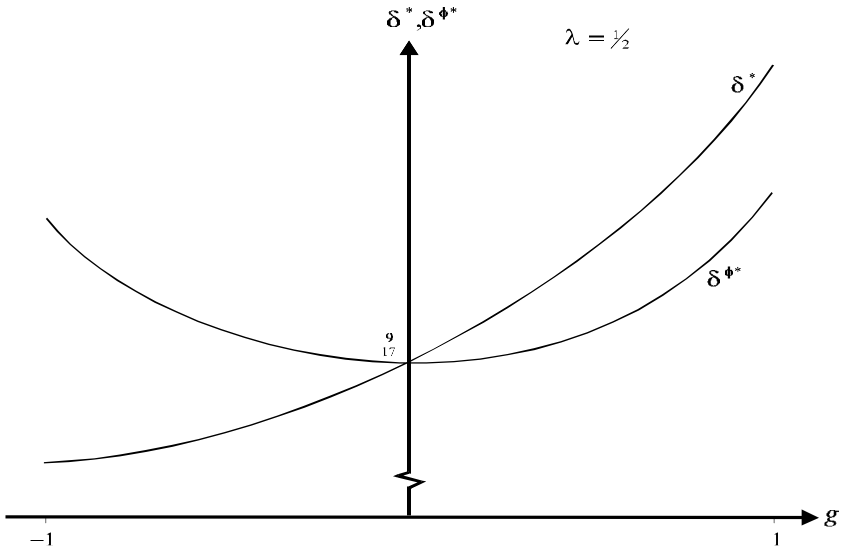


Fig. 7: One market collusion in centralized and decentralized firms

The result of a comparison of the potential of centralized and decentralized firms to collude in two markets depends on the sign and importance of the cost spillover as well as on λ.

In the case of **economies of scope**, delegation favors collusion if λ is not too high or economies of scope not so important (see also figure 8 a) below):

$$\delta^{\Phi **} \quad \begin{cases} < \delta^{**} & if \quad 0 < g < g^{crit}(\lambda) \\ \geq \delta^{**} & if \quad g \geq g^{crit}(\lambda) \end{cases}$$

where

$$g^{crit} \begin{cases} > -1 & if \quad \lambda = 0 \\ = \frac{1}{6}(9 - \sqrt{105}) \approx -0,208 & if \quad \lambda = 1. \end{cases}$$

Hence, if divisions do not perceive the benefit of their joint production, collusion is always easier

[30] However, as mentioned in section 4, we do not expect to observe one market collusion in centralized firms if they face diseconomies of scope. Comparing the critical discount factor for two market collusion in centralized firms ($\delta^{**}(\hat{s})$) with the discount factor for one market collusion in decentralized firms ($\delta^{\Phi *}$) for $g > 0$ would lead to the result, that collusion in one market in decentralized firms is always more difficult than collusion in (at least) one market in centrailized firms.

in divisionalized firms. If $\lambda = 1$, delegation only favors collusion if $g < \frac{1}{6}(9 - \sqrt{105})$.

If there are **diseconomies of scope**, a high λ favors collusion in decentralized firms. However, as soon as diseconomies of scope are getting important, it is always easier to collude in two markets if firms are centralized than if they were decentralized (see figure 8 b)):

$$\delta^{\Phi**} \quad \begin{cases} < \delta^{**} & if \quad 0 < g < g^{crit}(\lambda) \\ \geq \delta^{**} & if \quad g \geq g^{crit}(\lambda) \end{cases}$$

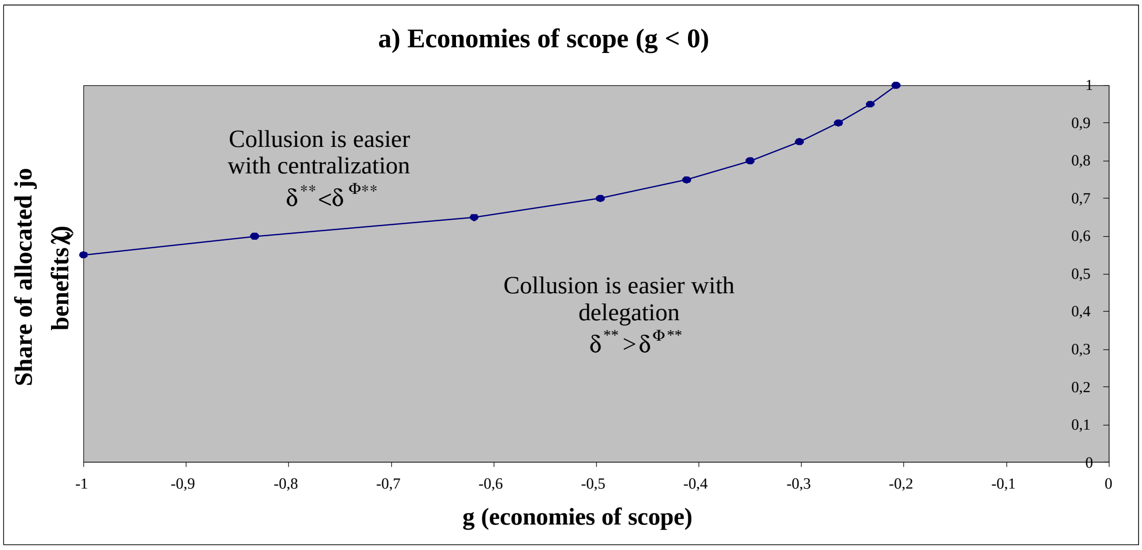
where

$$g^{crit} \approx \begin{cases} 0.206 & if \quad \lambda = 0 \\ 0.291 & if \quad \lambda = 1. \end{cases}$$

The following proposition can now be stated:

Proposition 7 *The collusive potential of multimarket firms facing intermarket cost linkages depends on their internal structure: One market collusion is easier in centralized firms in the case of economies of scope and easier in decentralized firms in the case of diseconomies of scope. Two market collusion tends to be favored by decentralization if firms face economies of scope and λ is small or if diseconomies of scope are very low. If diseconomies are getting more important, centralization favors collusion in both markets.*

In figure 8, the sustainability of collusion in centralized and decentralized firms is compared. It shows $\lambda - g$ combinations for which collusion is easier (more difficult) sustainable in decentralized than in centralized firms:



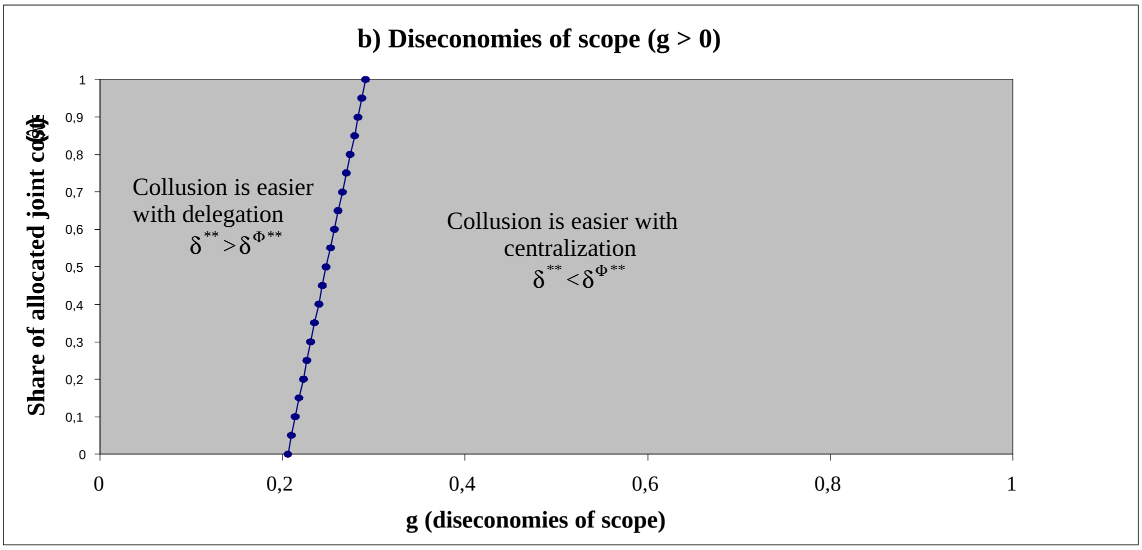


Fig. 8: Two market collusion in centralized and decentralized firms

7. Summary

In this paper it was asked how intermarket cost linkages affect collusion, and what role is played by the organizational choice of firms. Whereas in a model without intermarket cost linkages multimarket contact does not alter the incentive constraints of firms whenever firms and markets are identical, it was shown that the pooling of incentive constraints in the presence of scope effects (cost linkages across markets) does influence the collusive potential of firms. The influence of intermarket cost linkages on multimarket collusion depends crucially on the sign of the spillover effect. In the case of diseconomies of scope, it could be seen that the collusive potential of multimarket firms increases with the importance of the spillover effect. If economies of scope are considered, collusion becomes the more difficult, the higher the positive spillover effect.

As multimarket firms are very often complex structures where decisions are decentralized, the assumption of a central decision maker may not reflect real conditions. The impact of delegation of quantity decisions to independent divisional managers was therefore analyzed. It was first shown that the feasibility of collusion in divisionalized firms is influenced by the degree of allocation of joint costs to managers which determine the degree of managers' internalization of positive or negative spillover effects. As the cost allocation decisions of owners influence the level of costs as perceived by managers, the impact of cost allocation scheme resembled the influence of the cost interaction term on collusion. In the case of economies of scope, collusion becomes the more difficult, the more managers consider (joint) costs (and hence the higher are perceived costs), while in the case of diseconomies of scope, collusion is facilitated by full cost allocation. In a second step collusion in centralized and decentralized firms was compared. It was shown, that delegation - combined with adequate incentive schemes for managers - favors collusion if firms face economies of scope or if diseconomies of scope are small. The lack of coordination between markets then enhances the collusive power of firms. On the other hand, if diseconomies of scope are important, firms always do better to keep decisions centralized. Centralized firms are able to punish a deviator in all contact markets, which is the more severe, the higher are diseconomies of scope. Besides, centralization allows firms with multimarket contact to each specializing in one market and hereby to increase efficiency in production.

If we incorporated incentive schemes that tie managers' salary to a weighted average between divisional and cooperative profits, we get results that are similar results to the results derived in this paper. However, it might be worthwhile to generalize these results assuming more general demand and cost functions and allowing for both - managers' participation in corporate costs as well as their participation in corporate revenue.

In this paper the impact of the delegation and managers' incentive scheme on collusion was analyzed. It did not address the question which organizational form would actually be chosen by firms with multimarket contact. Analyzing the choice of the incentive scheme, there are two possible scenarios: It could either be assumed that owners choose the incentive scheme in a pre-stage of the game which is followed by the infinitively repeated Cournot game. In this case one would expect that owners choose "soft" or "aggressive" incentive scheme dependent on their expectations about future preferences of managers and the feasibility of collusion. It could also be assumed that owners choose the incentive scheme of managers in every period. One would then expect different incentive schemes for collusive periods and for punishment periods.

This paper was hence a first approach to underline the importance of the organizational structure of firms for collusion, and there remain a lot of open questions for future research.

Appendix A: One market collusion and output shares

Maximization of the joint collusive output yields:

$$\Pi^{CP} = \frac{a^2(3-g)^2}{4(3-g^2(1-3s+3s^2))^2}.$$

Differentiation with respect to s yields:

$$\begin{aligned} \frac{\partial \Pi^{CP}}{\partial s}(s &= \frac{1}{2}) = 0 \\ \frac{\partial (\Pi^{CP})^2}{\partial^2 s}(s &= \frac{1}{2}) > 0. \end{aligned}$$

Checking the boundary solution leads to

$$\begin{aligned} \frac{\partial \Pi^{CP}}{\partial s}(s &= 0) = -\frac{3a^2(3-g)^2 g^2}{2(3-g^2)^3} \leq 0 \\ \frac{\partial \Pi^{CP}}{\partial s}(s &= 1) = \frac{3a^2(3-g)^2 g^2}{2(3-g^2)^3} \geq 0. \end{aligned}$$

Hence, joint collusive profits are maximal with asymmetric output shares.

But for $s_i = 0$, one gets

$$\Pi_i^{CP} - \Pi_i^{PP} \leq 0 \quad \text{for} \quad g \leq\approx 0.72.$$

Therefore, even if $\delta = 1$, a joint profit maximizing collusive output is only attainable for very high diseconomies of scope. For $g \leq\approx 0.72$, the minimum output share which has to be allocated to each firm is near to $\frac{1}{2}$ (see fig. $A.1$).

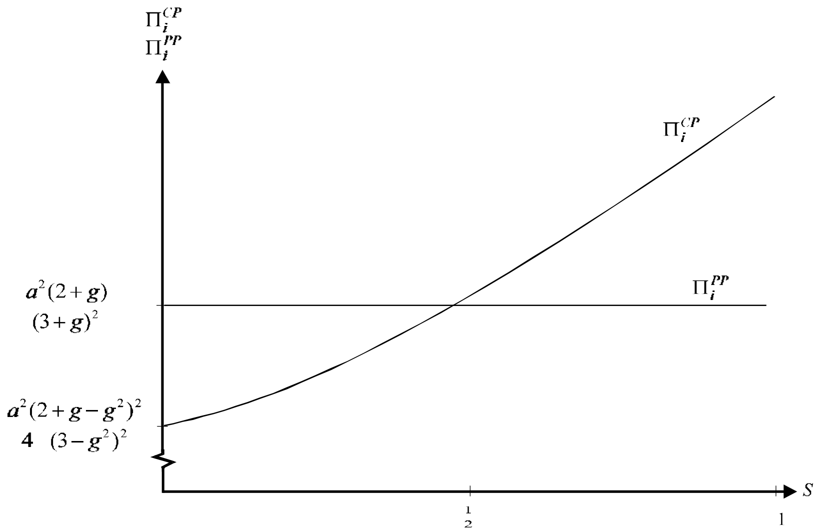


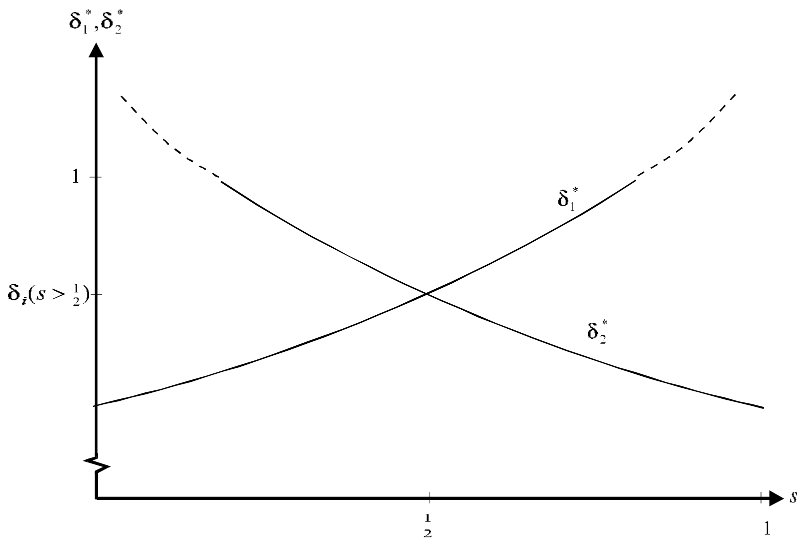
Fig. A.1: Collusion and punishment profits dependent on s ($g = \frac{1}{2}$)

The output share minimizing the relevant critical discount factor δ^* would be obtained by

$$\min_s \max_i [\delta_1^*, \delta_2^*].$$

For negative or not too high g, each firm's critical discount factor falls in its output share. For $s = \frac{1}{2}$, deviation profits as well as collusion profits are the same for both firms. Therefore, equal output shares at the same time minimize and equalize the critical discount factors. Numerical evaluations suggest, that only for very high g, asymmetric output shares would minimize the critical discount factor (see figure $A.2$).

a) Critical discount factors of both firms in dependence of s for $g = \frac{1}{2}$



b) Critical discount factors of both firms in dependence of s for $g = 0{,}8$

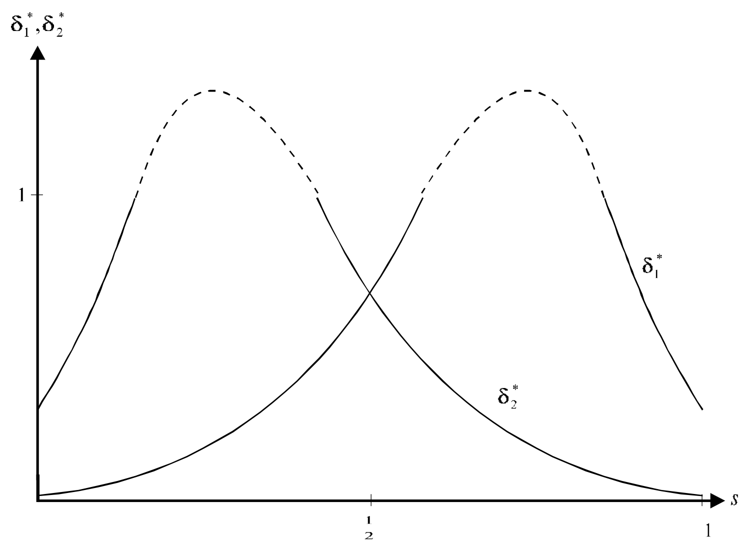


Fig. A.2: Influence of g on critical discount factors of both firms

Appendix B: One market collusion with and without cost linkages

Given $s = \frac{1}{2}$ in the case of intermarket cost linkages profits resulting from one market collusion and deviation from one market collusion are

$$\begin{aligned}\Pi_i^{CP} &= \frac{a^2(34 - 8g - 4g^2 + g^3)}{(12 - g^2)^2} \\ \Pi_i^{DP} &= \frac{a^2(135 - 38g - 49g^2 + 12g^3 + 4g^4 - g^5)}{(12 - g^2)^2(4 - g^2)}.\end{aligned}$$

Solving for the critical discount factor yields

$$\delta^* = \frac{(9 - g^2)^2}{153 - 48g - 44g^2 + 16g^3 + 3g^4 - g^5} \begin{cases} \geq \frac{9}{17} & for \quad g \geq 0 \\ < \frac{9}{17} & for \quad g < 0. \end{cases}$$

Appendix C: Pooled vs. separated incentive constraints

If firms defined trigger strategies for each market separately, deviation in market k would be punished in market k, whereas it would not affect collusion in the other market. The incentive constraint for each market would be

$$\begin{aligned} \Pi_i^{DC} + \frac{\delta}{1-\delta}\Pi_i^{PC} &\leq \frac{1}{1-\delta}\Pi_i^{CC} \quad \text{for } i = 1,2 \quad \text{(market } A\text{)} \\ \Pi_i^{CD} + \frac{\delta}{1-\delta}\Pi_i^{CP} &\leq \frac{1}{1-\delta}\Pi_i^{CC} \quad \text{for } i = 1,2 \quad \text{(market } B\text{)} \end{aligned} \tag{C-1}$$

or

$$\delta_i \geq \delta^{***} = \frac{\Pi_i^{DC} - \Pi_i^{CC}}{\Pi_i^{DC} - \Pi_i^{PC}} = \frac{\Pi_i^{CD} - \Pi_i^{CC}}{\Pi_i^{CD} - \Pi_i^{PC}} \quad \text{for } i = 1,2 \quad , k = A, B. \tag{C-2}$$

Two conditions must hold for the separation of punishment being a feasible strategy:

(1) To be a credible punishment strategy, one market collusion after deviation must be sustainable in the other market:

$$\delta_i \geq \delta^{*} = \frac{\Pi_i^{DP} - \Pi_i^{CP}}{\Pi_i^{DP} - \Pi_i^{PP}}. \tag{C-3}$$

(2) There must not be an incentive for firms to deviate in both markets, leading to two market punishment. Hence, the net gains from one market deviation should be equal or lower than the net gains from two market deviation, or:

$$\Pi_i^{DD} + \frac{\delta}{1-\delta}\Pi_i^{PP} - \frac{1}{1-\delta}\Pi_i^{CC} \leq \begin{cases} \Pi_i^{CD} + \frac{\delta}{1-\delta}\Pi_i^{CP} - \frac{1}{1-\delta}\Pi_i^{CC} & \text{(market A)} \\ \Pi_i^{DC} + \frac{\delta}{1-\delta}\Pi_i^{PC} - \frac{1}{1-\delta}\Pi_i^{CC} & \text{(market B).} \end{cases} \tag{C-4}$$

It is easy to see, that the second condition implies $\delta^{**} \leq \delta^{***}$.

Therefore, whenever one market punishment is a feasible strategy and one market collusion can be sustained, the threat of punishment in both markets would relax the incentive constraint for both markets. The collusive potential of firms with multimarket contact and cost linkages is therefore always increased if incentive constraints are pooled across markets.

Appendix D: Two market collusion and output shares

D.1 Joint profit maximizing output shares

Given joint profit maximizing supply decisions, collusive profits are

$$\Pi^{CC} = \frac{a^2}{2 + 2gs(1-s)}.$$

Solving the FOC for s leads to $s = \frac{1}{2}$. Second-order conditions are:

$$\frac{\partial^2 \Pi^{CC}}{\partial s^2}(s = \frac{1}{2}) = \frac{16a^2 g}{(4+g)^2} \begin{cases} < 0 & for \quad g < 0 \\ \geq 0 & for \quad g \geq 0. \end{cases}$$

Checking the boundary solutions yields:

$$\begin{aligned} \frac{\partial \Pi^{CC}}{\partial s}(s &= 0) = -\frac{ag}{2} < 0 \\ \frac{\partial \Pi^{CC}}{\partial s}(s &= 1) = \frac{ag}{2} < 0 \end{aligned}$$

Hence, collusive profits are maximal with equal output shares in case of economies of scope and with complete specialization in case of diseconomies of scope.

D.2 Deviation profit minimizing output shares

Differentiation of deviation profits with respect to s yields

$$\frac{\partial \Pi_i^{DD}}{\partial s} = (1-2s)M$$

with

$$M = -\frac{a^2(2 + 2g^3(1-s)s + g^2(2 - 5s + 5s^2) - g(1 + 2s - 2s^2))}{4(4-g^2)(1+g(1-s)s)^3} < 0.$$

$(1-2s)$ is a measure for the asymmetry of output shares across markets. If $s = \frac{1}{2}$, there is a local minimum of deviation profits:

$$\begin{aligned} \frac{\partial \Pi_i^{DD}}{\partial s} &= 0 \\ \frac{\partial (\Pi_i^{DD})^2}{\partial^2 s}(s &= \frac{1}{2}) > 0. \end{aligned}$$

For $s < \frac{1}{2}$, $(1-2s) > 0$ and the first order derivative must be negative, whereas it is positive for $s \geq \frac{1}{2}$. Hence deviation profits are minimal with symmetric output share and rise in the asymmetry of output shares.

The minimal critical discount factor in the case of diseconomies of scope If we check the first and second derivative for $s = \frac{1}{2}$, we get

$$\begin{aligned} \frac{\partial \delta^{**}}{\partial s}(s &= \frac{1}{2}) = 0 \\ \frac{\partial (\delta^{**})^2}{\partial^2 s}(s &= \frac{1}{2}) > 0. \end{aligned}$$

Consequently, at $s = \frac{1}{2}$ there is a local minimum of the critical discount factor, irrespective of the sign of g.

Checking the boundary solutions yields:

$$\begin{aligned} \frac{\partial \delta^{**}}{\partial s}(s &= 1) > 0 \quad for\ g < -2 + \sqrt{5} \\ \frac{\partial \delta^{**}}{\partial s}(s &= 1) \leq 0 \quad for\ g \geq -2 + \sqrt{5}. \end{aligned}$$

Hence, for $g \leq -2 + \sqrt{5}$, there is a unfavorable effect of specialization on the critical discount factor. For $g \geq -2 + \sqrt{5}$ asymmetric output shares lead to another local minimum, which implies specialization. Comparing the interior solution with the asymmetric solution, we get

$$\delta^{**}(s = 1) \begin{cases} > \delta^{**}(s = \frac{1}{2}) & for \quad g <\approx 0.21 \\ \leq \delta^{**}(s = \frac{1}{2}) & for \quad g \geq\approx 0.21. \end{cases}$$

For $g <\approx 0.21$ a choice of symmetric output shares facilitates collusion in comparison to complete specialization. When g becomes more important, asymmetric output shares minimize the critical discount factor and at the same time lead to higher collusive profits. But as the boundary solution is not locally optimal for $g < -2 + \sqrt{5}$, there must be other asymmetric solutions minimizing δ^{**}. We therefore define

$$\hat{s} = \begin{cases} \frac{1}{2} & for \quad g <\approx 0.21 \\ 0 < s < \frac{1}{2} & for \quad \approx 0.21 \leq g < -2 + \sqrt{5} \\ 1 & for \quad g \geq -2 + \sqrt{5} \end{cases}$$

as the output share minimizing the critical discount factor in case of two market collusion.

Appendix E: Equal output shares in case of divisionalization

Collusion (say in market A) is sustainable, if

$$\delta \geq \delta_i^{A*(.)} = \frac{\Pi_i^{D\cdot} - \Pi_i^{C\cdot}}{\Pi_i^{D\cdot} - \Pi_i^{P\cdot}}$$

where there could be collusion or Cournot-Nash play in the other market. It is easy to see, that collusion as well as deviation profits must rise in s, as the share of total market supply rises: Collusion profits rise as the share of the collusive revenue rises, whereas deviation profits rise because of the decrease of the other firm's output. Punishment profits are independent of s. For $x^{D\cdot} = \frac{1}{2}(a - (1-s)x^{C\cdot} - gy^{C\cdot})$ we get

$$\frac{\partial(\Pi_i^{D\cdot} - \Pi_i^{C\cdot})}{\partial s} = -\frac{1}{2}(x^{C\cdot} + (1-s_i)\frac{\partial x^{C\cdot}}{\partial s_i} + g\frac{\partial y^{C\cdot}}{\partial s_i})(a - x^{C\cdot}(1+s_i) - gy_1^{C\cdot}).$$

As

$$\begin{aligned} g\frac{\partial y^{C\cdot}}{\partial s_i} &\geq 0, \\ (1-s_i)\frac{\partial x^{C\cdot}}{\partial s_i} &= -(1-s_i)\frac{1}{2}g(y_1^{C\cdot} - y_2^{C\cdot}) < x^{C\cdot} \\ a - x^{C\cdot}(1+s_i) - gy_1^{C\cdot} &\geq 0 \end{aligned}$$

it follows, that

$$\frac{\partial(\Pi_i^{D\cdot} - \Pi_i^{C\cdot})}{\partial s_i} < 0.$$

This is easier to see, if $g = 0$:

$$\frac{\partial(\Pi_i^{D\cdot} - \Pi_i^{C\cdot})}{\partial s_i} = -\frac{1}{2}x^{C\cdot}(a - x^{C\cdot}(1+s_i)) \leq 0$$

As $\Pi_i^{P\cdot}$ is independent of s, and $\Pi_i^{D\cdot}$ is increasing in s, it follows that

$$\frac{\partial(\Pi_i^{D\cdot} - \Pi_i^{P\cdot})}{\partial s_i} \geq 0$$

But this implies that

$$\frac{\delta_i^{A*(.)}}{\partial s_i} = \frac{\partial}{\partial s}(\frac{\Pi_i^{D\cdot} - \Pi_i^{C\cdot}}{\Pi_i^{D\cdot} - \Pi_i^{P\cdot}}) \leq 0.$$

If the critical discount factor of each firm is decreasing in the output share allocated to it, the output share minimizing the critical discount factor for both firms must be $s_i = \frac{1}{2}$.

Appendix F: Critical discount factors for two market collusion

Dependent on the sustainability of one market collusion, there are two potential incentive constraints for two market collusion:

$$IC1 \quad : \quad \delta \geq \delta^{\Phi**1} = \frac{\Pi_i^{\Phi ADC} - \Pi_i^{\Phi ACC}}{\Pi_i^{\Phi ADC} - \Pi_i^{\Phi kPP}}, \qquad if \quad \delta < \delta^{\Phi*} \qquad \text{(one market collusion is not sustainable)}$$
$$IC2 \quad : \quad \delta \geq \delta^{\Phi**2} = \frac{\Pi_i^{\Phi ADC} - \Pi_i^{\Phi kCC}}{\Pi_i^{\Phi ADC} - \Pi_i^{\Phi APC}}, \qquad if \quad \delta \geq \delta^{\Phi*} \qquad \text{(one market collusion is sustainable).}$$

Inserting deviation, collusion and punishment profits into $eqs. 7.10'$ and $7.11'$ yields

$$\delta^{\Phi**1} = \frac{(3+\lambda g)^2}{17 + 22\lambda g + 5(\lambda g)^2}$$
$$\delta^{\Phi**2} = \frac{(12-(\lambda g)^2)^2}{272 - 88(\lambda g)^2 + 5(\lambda g)^4}.$$

Comparison with the critical discount factor for one market collusion, $\delta^{\Phi*}$, yields:

$$\delta^{\Phi**2} < \delta^{\Phi*} < \delta^{\Phi**1} \quad for \quad g < 0$$
$$\delta^{\Phi**1} < \delta^{\Phi**2} < \delta^{\Phi*} \quad for \quad g > 0.$$

Figure $E.1$ shows the potential critical discount factor for one and two market collusion:

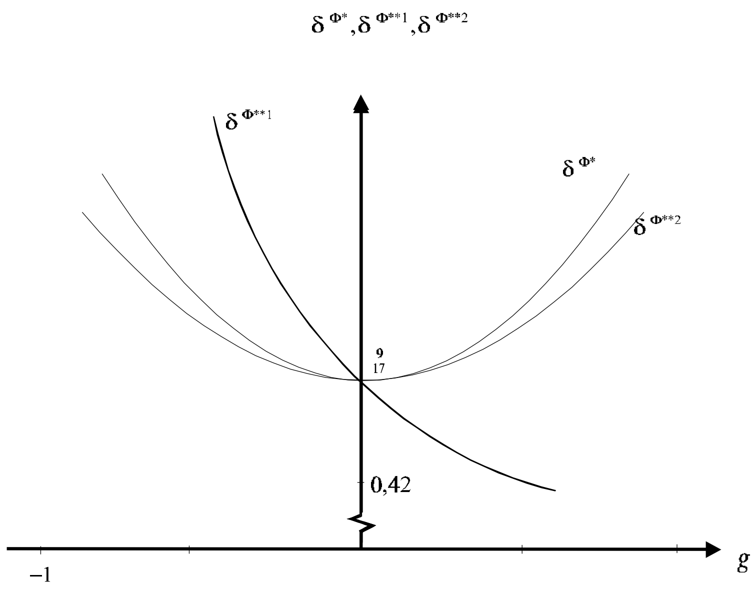


Fig. E.1: $\delta^{\Phi*}$, $\delta^{\Phi**1}$ and $\delta^{\Phi**2}$ in dependence of g ($\lambda = 1$)

It is easy to see that $\delta^{\Phi**2}$ ($IC2$) is never relevant: $\delta^{\Phi**2}$ presumes that one market collusion is sustainable after deviation in the other market . But, as $\delta^{\Phi*} > \delta^{\Phi**2}$, there is a range of δ where $\delta > \delta^{\Phi**2}$, but one market collusion cannot be sustained ($\delta^{\Phi*} > \delta > \delta^{\Phi**2}$). In this range, $IC2$ leads to a contradiction. If $\delta \geq \delta^{*}$, one market collusion is sustainable. However, given collusion in one market, collusion in the other market is also feasible. Therefore $\delta^{\Phi*}$ is at the same time the critical discount factor for one and two market collusion.

Furthermore, it can be seen that $IC1$ can only be fulfilled only where there are diseconomies of scope ($g < 0$), but not where there are economies of scope ($g > 0$):

$IC1$ is fulfilled, if

$$\delta \geq \delta^{\Phi**1} \quad given \quad \delta < \delta^{\Phi*}.$$

It follows that

$$\delta^{\Phi *} \geq \delta^{\Phi **1}$$

But we saw above, that

$$\delta^{\Phi *} < \delta^{\Phi **1}$$

which leads to a contradiction.

Hence, for $g < 0$, $\delta^{\Phi *}$ is the relevant critical discount factor for one and for two market collusion:

$$\delta^{\Phi **} = \delta^{\Phi *}$$

For $g > 0$, two market collusion is easier to sustain than one market collusion and is possible whenever $\delta \geq \delta^{\Phi **1}$. Therefore, the critical discountfactor for two market collusion is

$$\delta^{\Phi **} = \delta^{\Phi **1}$$

If $\delta^{**2} \leq \delta < \delta^{*}$, $IC1$ is the relevant incentive constraint. If one market collusion is possible ($\delta \geq \delta^{\Phi *}$), $IC2$ is relevant.

Appendix G: The impact of λ

$$\frac{\partial \delta^{\Phi *}}{\partial \lambda} = \frac{48 g^2 \lambda (108 - 21 (g\lambda)^2 + (g\lambda)^4)}{(153 - 66 (g\lambda)^2 + 5 (g\lambda)^4)^2} > 0 \text{ in the relevant range of } g \text{ and } \lambda$$

$$\frac{\partial \delta^{\Phi **}}{\partial \lambda} = -g \frac{8(12 + 7(g\lambda) + (g\lambda)^2)}{(17 + 22(g\lambda) + 5(g\lambda)^2)^2} \begin{array}{lll} > 0 & if & -1 \leq g < 0 \\ \leq 0 & if & g \geq 0. \end{array}$$

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